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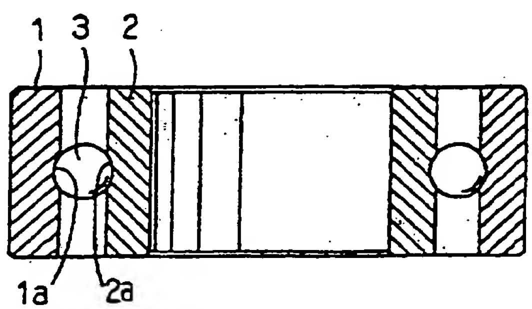
INT CL^6 **F16C**

(54) **Rolling bearing**

(57) In a rolling bearing, at least one of the inner ring (2) or shaft (4) and the outer ring (1) is made of a martensitic stainless steel composed of 0.60 to 0.75 weight % of carbon, 10.5 to 13.5 weight % of chromium, 1.0 weight % or less of silicon and 0.3 to 0.8 weight % of manganese, the remainder of the composition being iron and inevitably introduced impurities, having a hardness of HRC 58 or above, containing eutectic carbide particles of 10μm and below in diameter, and having oxygen and titanium concentrations each of 10 ppm or below. The material allows highly accurate machining for precision applications. The rolling elements may be made of high carbon chromium bearing steel.

F I G. 1



F I G. 2

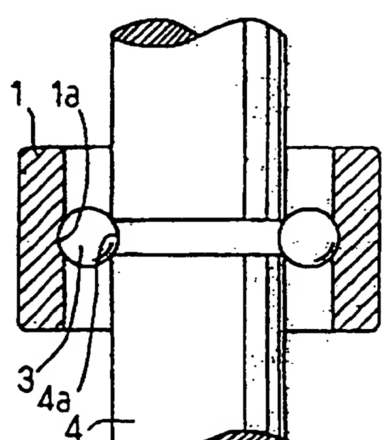


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FIG. 1

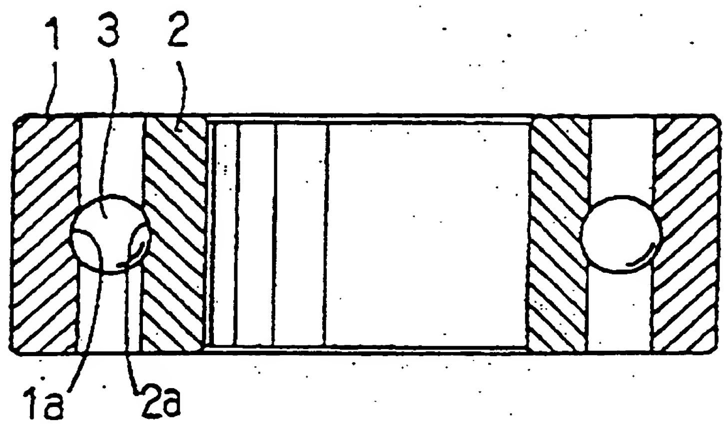
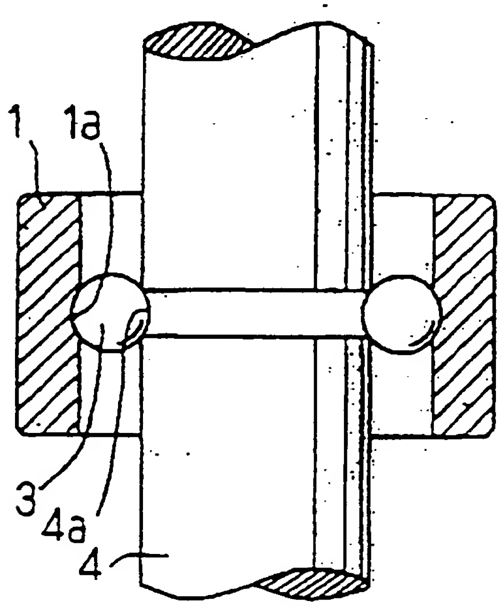


FIG. 2



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ANTI-FRICTION BEARING

This invention relates to anti-friction bearings and, more particularly, to anti-friction bearings suitable for rotary parts of precision apparatus.

An anti-friction bearing usually comprises an inner ring, an outer ring and rolling elements. These constituent elements are usually made of the same material, high carbon chromium bearing steel, "SUS440C" (JIS Standard) class martensitic stainless steel, and stainless steel are typically used for anti-friction bearing elements which are required to have corrosion resistance.

Stainless steel is satisfactorily corrosion-resistant. However, it contains large diameter particles such as eutectic carbides, which are generated by eutectic reactions taking place during solidification of molten steel, and alumina and other non-metallic substances, which are generated as a result of chemical changes of impurities contained in the raw material of molten steel. Such eutectic carbides and non-metallic substances give rise to different steel cutting properties from the steel structure *in situ* and prevent highly accurate cutting. Particularly, they prevent highly accurate finishing of the raceway grooves in the inner and outer rings of anti-friction bearings. Consequently, it is impossible to improve the rotational accuracy, and great noise is generated by vibrations which are caused during rotation. Therefore, it

has been impossible to use this stainless steel for rotary parts of precision apparatus such as precision measuring instruments or computer peripherals.

To improve the processing accuracy of the stainless steel used for anti-friction bearings in the prior art, the eutectic carbide particles are made finer in diameter, for instance to about 10 μm, by a heat treatment in the steel manufacturing process. However, no stainless steel is available which is manufactured by suppressing the generation of non-metallic substances. At any rate, it has been impossible to fabricate highly accurate anti-friction bearings.

An object of the invention is to provide quiet anti-friction bearings by fabricating inner and outer rings thereof with a stainless steel, which is made more homogeneous and denser in structure by making eutectic carbide particles contained in it to be finer and also suppressing the generation of non-metallic substances in it to an extremely low level.

To attain the above object, in an anti-friction bearing according to a first aspect of the invention, which comprises rolling elements provided in raceway grooves of an inner and an outer ring, at least one of said inner ring and outer rings being made of a martensitic stainless steel composed of, in percentages by weight, 0.60 to 0.75% of carbon, 10.5 to 13.5% of chromium, 1.0% or below of silicon, and 0.3 to 0.8% of manganese, the remainder of the

composition being iron and inevitably introduced impurities, has a hardness of HRC 58 or above, contains eutectic carbide particles of 10 μm and below in diameter, and has oxygen and titanium concentrations each of 10 ppm or below.

In an anti-friction bearing according to a second aspect of the invention, which comprises a shaft having a raceway groove formed in the outer periphery, an outer ring having a raceway groove formed in the inner periphery, and rolling elements formed in the raceway grooves of the inner and outer rings, at least one of the shaft and the outer ring is made of a martensitic stainless steel composed of, in percentages by weight, 0.60 to 0.75% of carbon, 10.5 to 13.5% of chromium, 1.0% or below of silicon, 0.3 to 0.8% of manganese, the remainder of the composition being iron and inevitably introduced impurities, having a hardness of HRC 58 or above, containing eutectic carbide particles of 10 μm and below in diameter, and having oxygen and titanium concentrations each of 10 ppm or below.

In one form of the invention, the rolling elements are made of high carbon chromium bearing steel.

Specific embodiments of the anti-friction bearing according to the invention will now be described with reference to the annexed drawings in which:

FIG. 1 is a sectional view showing an embodiment of the anti-friction bearing according to the invention; and

FIG. 2 is a sectional view showing a different

embodiment of the anti-friction bearing according to the invention.

Referring to Fig. 1, reference numeral 1 designates an outer ring having a raceway groove 1a formed in the inner periphery, and 2 an inner ring having a raceway groove 2a formed in the outer periphery. A plurality of balls 3 are provided as rolling elements between the raceway grooves of the inner and outer rings.

In this embodiment of the anti-friction bearing, the outer and inner rings 1 and 2 are made of a peculiar stainless steel as described below, and the balls 3 are made of high carbon chromium bearing steel.

The stainless steel constituting the inner and outer rings is composed of 0.60 to 0.75% of carbon, 10.5 to 13.5% of chromium, 1.0% or below of silicon and 0.3 to 0.8% of manganese, all percentages being by weight, the remainder of the composition being iron and inevitably introduced impurities, has a hardness of HRC 58 or above, contains eutectic carbide particles of 10μm and below in diameter as set by heat treatment control, and has oxygen and titanium concentrations each of 10 ppm or below.

According to the invention, the titanium concentration in the stainless steel is kept to 10 ppm or below by using a raw material with an extremely low content of titanium as impurity, thus reducing to an extremely low level the generation of non-metallic substances which stem from titanium, such as titanium nitride generated by combination

of titanium and nitrogen in the molten steel.

In the process of manufacturing the stainless steel according to the invention, the oxygen concentration in the stainless steel can be reduced to 10 ppm or below by extending the time of purging gases from the molten steel, thus also suppressing to an extremely low level the generation of non-metallic substances which stem from oxygen, such as alumina generated by combination of a slight amount of aluminium contained in the raw material of the stainless steel and oxygen or silicon nitride generated by combination of silicon in the raw material and oxygen.

Since the stainless steel constituting the inner and outer rings of the ball bearing as described above has eutectic carbide particles of reduced diameter and contains an extremely low level of generated non-metallic substances, it has a homogeneous and dense metallic structure and permits highly accurate machining, thus permitting improvement of the quietness and rotational accuracy of the ball bearing.

Table 1 given below shows the results of tests which were conducted on this embodiment of the anti-friction ball bearing to determine vibrations and noise (or quietness). The tests were conducted in conformity to the AFBMA (The Anti-Friction Bearing Manufacturing Association, Inc.) Standards. The Table also shows for comparison the results of tests conducted on a ball bearing made of the conventional "SUS440C" (JIS Standard) class stainless

steel. The test results are shown as Andelon values.

As according to the invention, in the prior art stainless steel ball bearing the high carbon chromium bearing steel was used for the balls.

(Table 1)

	Andelon value	
	M	H
Stainless steel ball bearing according to the invention	0.270	0.200
Prior art stainless steel ball bearing	0.473	0.418

In Table 1, the Andelon value columns shown as M and H correspond to respective measurement frequency bands, the column M corresponding to a medium frequency band (300 to 1,800 Hz) and the column H corresponding to a high frequency band (1,800 to 10,000 Hz). As shown, the smaller the Andelon value, the lower the level of vibrations and noise and the quieter the bearing.

Fig. 2 shows a different embodiment of the invention, in which a plurality of balls are provided in an inner raceway groove 4a formed in the outer periphery of a shaft 4 and an outer raceway groove 1a formed in the inner periphery of an outer ring 1.

Like the above first embodiment shown in Fig. 1, in this embodiment the outer ring 1 and the shaft 4 are made of the stainless steel noted above, and the balls 3 are made of high carbon chromium bearing steel.

In the above first embodiment both the outer and inner rings 1 and 2, and in the second embodiment both the outer ring 1 and the shaft 4, were made of the stainless steel according to the invention. Depending on applications, however, only one of the two components (i.e. the outer ring 1 and the inner ring 2 or the outer ring 1 and the shaft 4) which is required to have high corrosion resistance and stable bonding strength, may be made of the stainless steel according to the invention, while using the high carbon chromium bearing steel for the other component.

The stainless steel for anti-friction bearings according to the invention, having the constitution as described above, has the following functions and effects. Since the titanium and oxygen concentrations in the stainless steel are each kept to 10 ppm or below while the generation of non-metallic substances is suppressed to an extremely low level, the stainless steel has a homogeneous and dense structure and permits highly accurate finish of the raceway grooves when used as the material of the anti-friction bearing, thus permitting a great improvement in the quietness and rotational accuracy of the anti-friction bearing.

The non-metallic substances contained in the stainless steel are hard compared to the stainless steel *in situ*, and with the conventional stainless steel anti-friction bearing the non-metallic substances which are present on the surface of the raceway grooves of the anti-friction bearing

cause wear of the surface of the rolling elements. With the stainless steel as the material of the anti-friction bearing according to the invention, in which non-metallic substance content is suppressed to an extremely low level, the rolling elements are less worn, and the life of the anti-friction bearing can be extended.

Moreover, while the inner and outer rings and the shaft which constitute surfaces of the anti-friction bearing and should be corrosion-resistant are made of stainless steel, the rolling elements which are provided inside the bearing and do not require corrosion resistance, may be made of the high carbon chromium bearing steel which can readily be highly accurately machined and is inexpensive compared to the stainless steel, thus providing excellent corrosion resistance, rotational accuracy and quietness while also reducing the cost compared to an anti-friction bearing with all the constituent elements thereof made of stainless steel.

CLAIMS:

1. An anti-friction bearing comprising a plurality of rolling elements provided in raceway grooves formed in an inner and an outer ring, at least one of said inner and outer rings being made of a martensitic stainless steel composed of, in percentages by weight, 0.60 to 0.75% of carbon, 10.5 to 13.5 of chromium, 1.0% or less of silicon and 0.3 to 0.5% of manganese, the remainder of the composition being iron and inevitably introduced impurities, having a hardness of HRC 58 or above, containing eutectic carbide particles of 10μm or below in diameter, and having oxygen and titanium concentration each of 10 ppm or below.

2. An anti-friction bearing comprising a shaft having a raceway groove formed in the outer periphery, an outer ring having a raceway formed in the inner periphery, and a plurality of rolling elements provided in said raceway grooves of said shaft and said outer ring, at least one of said shaft and said outer ring being made of a martensitic stainless steel composed of, in percentages by weight, 0.60 to 0.75% of carbon, 10.5 to 13.5% of chromium, 1.0% or below of silicon, and 0.3 to 0.8% of manganese, the remainder of the composition being iron and inevitably introduced impurities, having a hardness of HRC 58 or above, containing eutectic carbide particles of 10μm and below in diameter, and having oxygen and titanium concentrations each of 10 ppm or less.